Temporary carbon sequestration cannot prevent climate change

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Storing carbon (C) in biosphere sinks can reduce atmospheric CO2 concentrations in the short term. However, this lowers the concentration gradient between the atmosphere and the oceans and other C reservoirs, and consequently reduces the rate of CO2 removal from the atmosphere. If C is then released again, subsequent CO2 concentrations will then be higher than without temporary C storage. It is thus important to analyse whether temporary C storage can mitigate climate-change impacts. This requires an explicit quantification of climate-change impacts. Impacts can be quantified:

1) as the instantaneous effect of increased temperature;
2) through the rate of temperature increase;
3) as the cumulative effect of increased temperatures.

Temporary C storage only reduces climate-change impacts related to the cumulative temperature effect and could even worsen impacts via the instantaneous effect of temperature or the rate of temperature change. When 1 tC is stored in the biosphere (Fig. 1a), the atmospheric content is initially lowered by 1tC (Fig. 1b). This reduces the CO2 gradient between the atmosphere and the oceans so that less C is removed from the atmosphere than without the biosphere sink. In the years after the initial sink activity, the atmospheric content is, therefore, progressively reduced by less than 1 tC, and after 20 years, it is reduced by only about 0.5 tC (Fig. 1b). If C is then released again, the atmospheric CO2 content (Fig. 1b) and resultant temperature (Fig. 1c) will be higher than it would have been without temporary storage. Figure 2 compares the benefits of temporary C storage in sinks established in 2000 and maintained for different lengths of time. Temporary C storage is only useful for impacts related to cumulative temperature effects, for which benefits accrue over time (Figure 2). For instantaneous temperature impacts and impacts via the rate of change, however, temporary storage actually worsens maximum climate-change impacts, and the longer C is stored the worse the effect becomes. C storage is only beneficial if it is maintained for so long that it approaches the time when maximum impacts are experienced. On average across the three kinds of climatic impacts, there is almost no mitigation potential for C storage for less than 50 years. This applies under both high and low emission scenarios. This has also implications for other greenhouse gases: N2O and other long-lived greenhouse gases have climatic impacts both through cumulative effects and by increasing the temperature in those future years when climatic impacts might be at their worst. CH4, on the other hand, is so short-lived that any currently emitted methane will have broken down by the time that most severe impacts will be experienced. Because it is currently quantified through its cumulative temperature effect, its overall detrimental contribution to climate-change impacts is therefore over-estimated. Because temporary C storage improves some, but worsens other climate-change impacts, it achieves very little on average. It is, therefore, not warranted to provide policy incentives for temporary C storage. For all greenhouse gases, we need a quantification of warming potentials that explicitly assesses the effects of different climatic impacts.

Figure 1. The effect of a 1 tC sink on atmospheric C content (b) and temperature (c). A sink is established in 2000 and C is either released again in 2020 (dashed lines) or retained (solid lines). Numbers are expressed relative to the situation without sink activity.

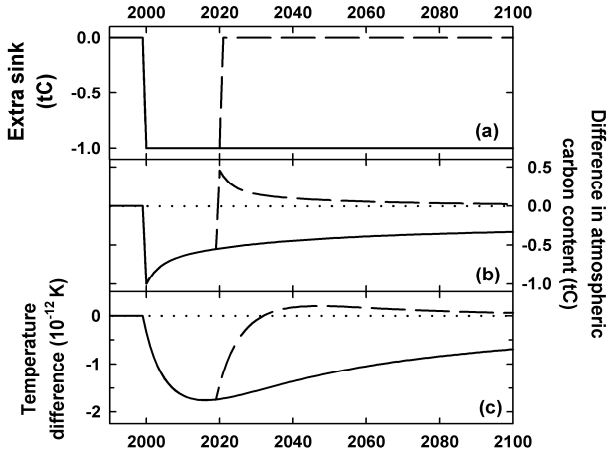

Figure 2. Comparison between fossil-fuel savings and temporary sinks maintained for different lengths of time under both the SRES A2 and SRES B1 scenarios. Each point represents a sink established in 2000 and maintained for different lengths of time before C is released again. This is compared with fossil-fuel savings in terms of its effect on maximum climate-change impacts up to 2100 for instantaneous temperature impacts (T), impacts via the rate of change (Δ) and via cumulative temperature (Σ) and for the average for the three kinds of impacts.